

NATIONAL ROUNDAABOUT PERSPECTIVES



Topics Covered Today

- History
- Policy
- Design Philosophy
- Capacity Software
- Striping
- Lighting

U.S. Modern Roundabout History

1990	First Modern Roundabout in Nevada
1992	Florida's first Modern Roundabout
1993	Maryland's first Modern Roundabout
1995	Vermont's first Modern Roundabout
1998	North Carolina's first Modern Roundabout
2000	New York's first Modern Roundabout
2004	Pennsylvania's first Modern Roundabout
2004	Virginia's first Modern Roundabout
2004	Delaware's first Modern Roundabout

Leading Roundabout States

Colorado	> 150
Washington	> 100
Utah	> 90
Maryland	> 80
North Carolina	> 40
Oregon	> 35
Florida	> 30
Kansas	> 25
California & Nevada	> 20 each
New York	24, with > 80 in design throughout state

States Actively Progressing Roundabouts



Safety Impacts of Modern Roundabouts

<u>Type of Roundabout</u>	<u>Converted from</u>	<u># of Conversions</u>	<u>Percent Reduction of all Crashes</u>	<u>Percent Reduction of Injury Crashes</u>
Single Lane, Urban	Stop Controlled	12	69%	80%
Single Lane, Rural	Stop Controlled	9	65%	68%
Multi-lane, Urban	Stop Controlled	7	8%	73%
Urban	Signalized	5	37%	75%
All		33	47%	72%

POLICY – SOME STATES ALREADY REQUIRE ROUNDBOUT CONSIDERATION

- MARYLAND
- WASHINGTON
- WISCONSIN
- NEW YORK

Excerpts from Draft HDM Chapter 5


5.9.1 Types of Intersections

General objectives for intersection design are:

- To provide adequate sight distances.
- To minimize points of conflict.
- To simplify conflict areas.
- To limit conflict frequency.
- To minimize severity of conflicts.
- To minimize delay.
- To provide acceptable capacity for the design year.

Roundabouts are frequently able to address the above objectives better than other intersection types in both urban and rural environments and on high- and low-speed highways. Thus, when a project includes reconstructing or constructing new intersections, a roundabout alternative is to be analyzed to determine if it is a feasible solution based on site constraints, including ROW, environmental factors, and other design constraints. Exceptions to this requirement are where the intersection:

- Has no current or anticipated safety, capacity, or other operational problems.
- Is within a well working coordinated signal system in a low-speed (<80 km/h) urban environment with acceptable accident histories.
- Is where signals will be installed solely for emergency vehicle preemption.
- Has steep terrain that makes providing an area, graded at 5% or less for the circulating roadways, infeasible.
- Has been deemed unsuitable for a roundabout by the Roundabout Design Unit.




When the analysis shows that a roundabout is a feasible alternative, it should be considered the Department's preferred alternative due to the proven substantial safety benefits and other operational benefits.

Designers should refer to the roundabout pages on the Department's Internet and IntraDOT sites for the latest requirements, guidance, and public involvement materials for roundabouts. Additionally, designers should contact their Regional expert or the Roundabout Unit in the Design Services Bureau for guidance and assistance throughout the development of the roundabout design.

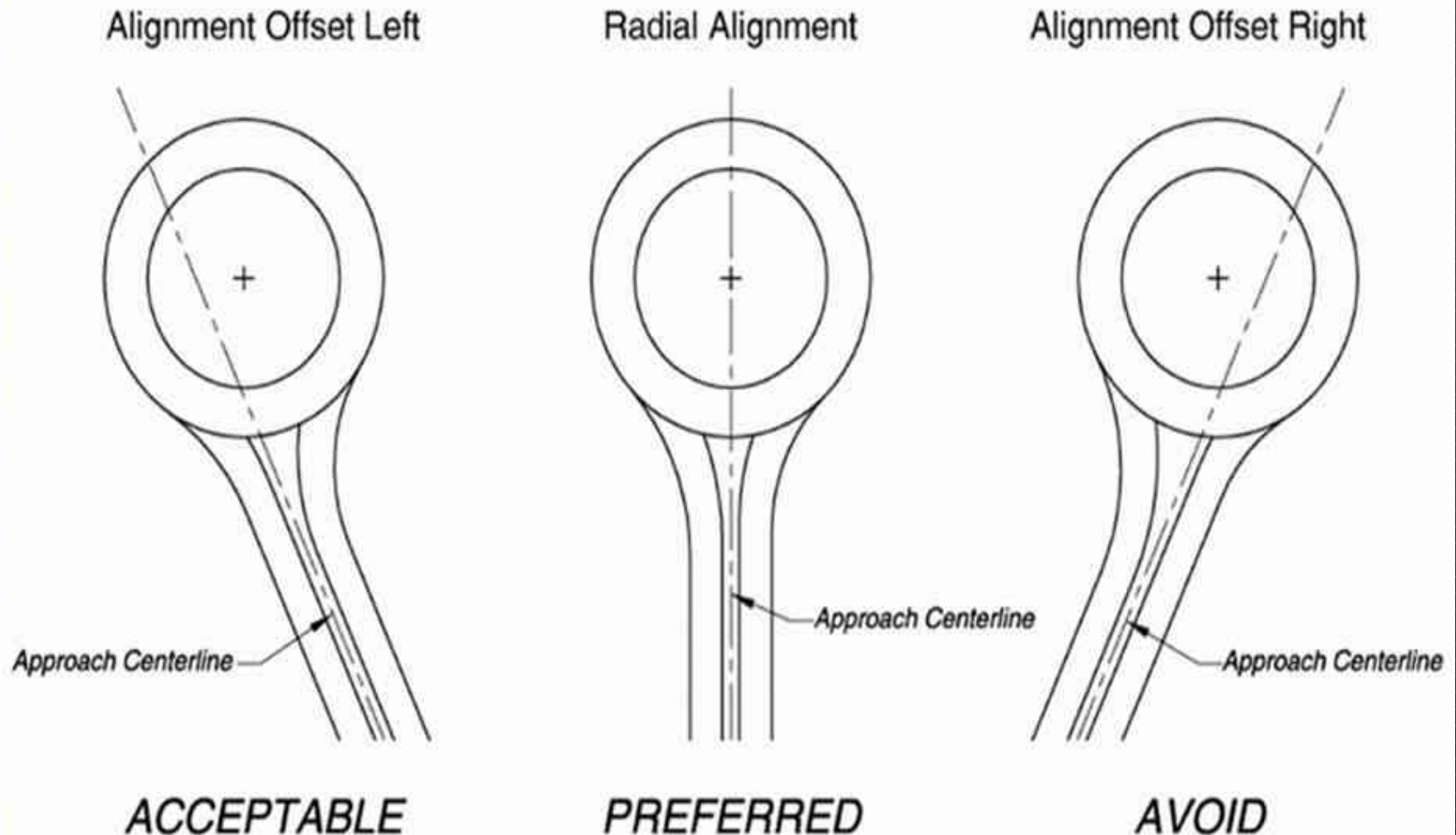
The initial layout, preliminary plans, and advance detail plans for the roundabout should be reviewed by designers with considerable roundabout design experience. For multi-lane roundabouts, roundabouts with more than 4 legs, and roundabouts with unusual geometry, the Roundabout Unit should be included in the review by e-mailing the ProjectWise location to roundabouts@dot.state.ny.us.

5.9.7 Signalization

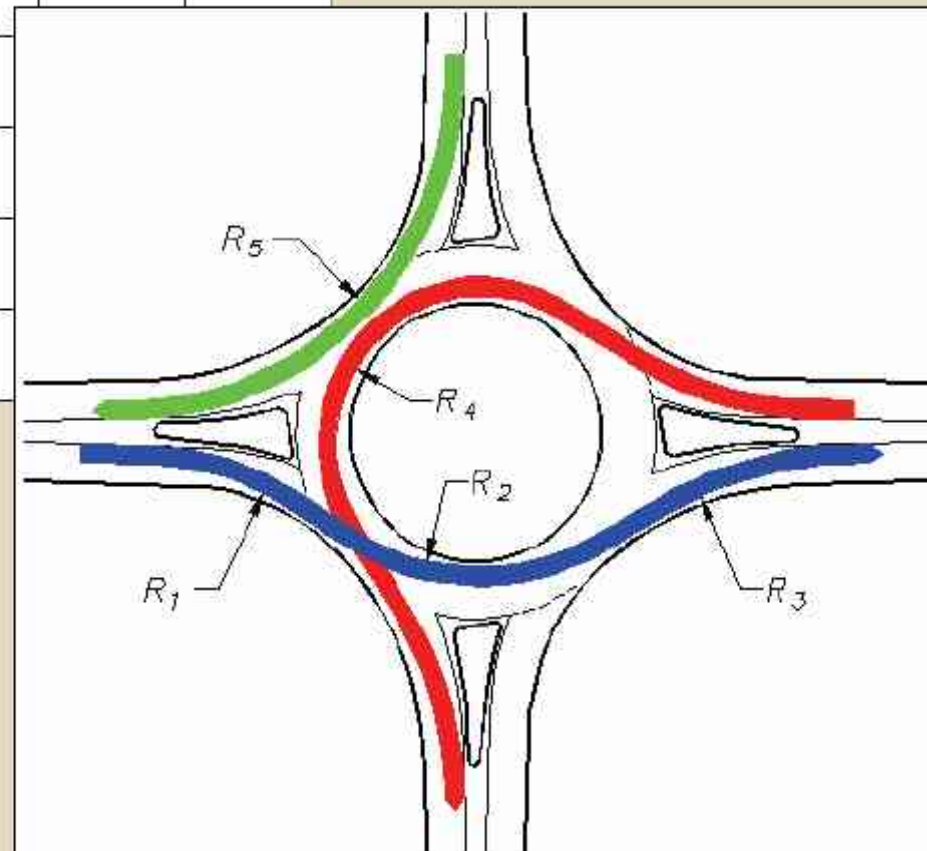
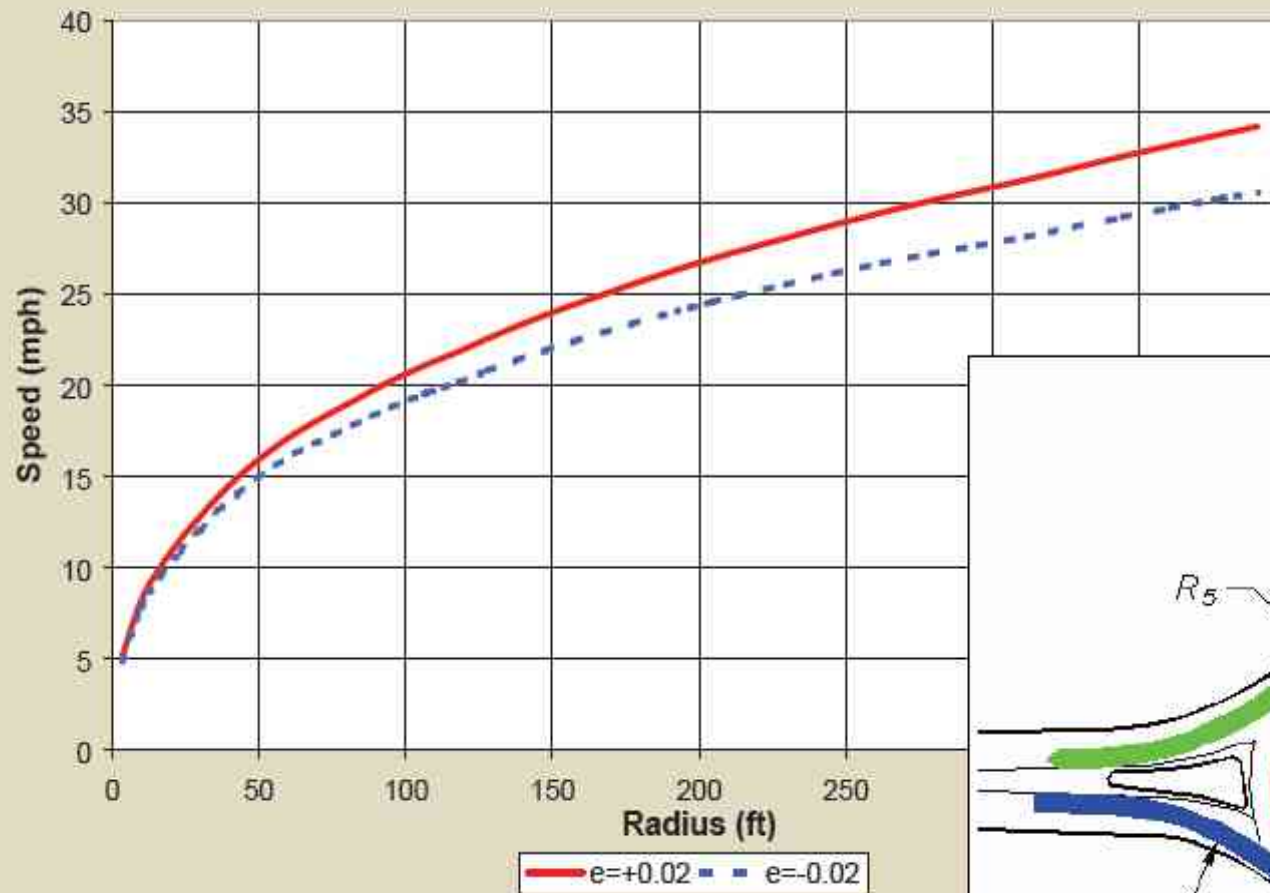


Before deciding to build a new signalized intersection or make major improvements to an existing signalized intersection (e.g., reconfigure the intersection, major widening on more than one approach), the alternative of using a roundabout is to be analyzed per Section 5.9.1 of this chapter.

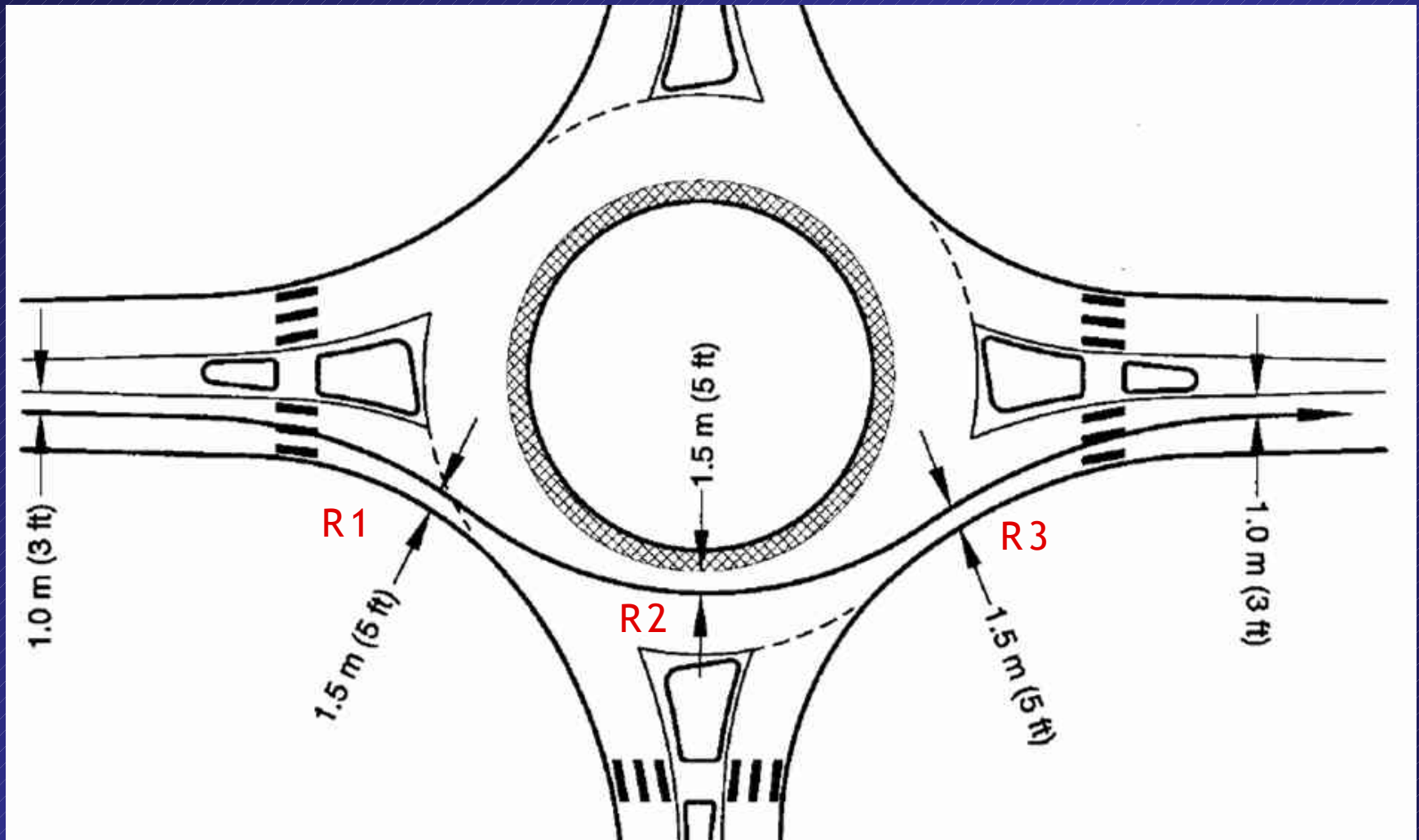
Design Philosophy - FHWA Guide Recommendations



Current FHWA speed prediction method is based on AASHTO speed-radius function.

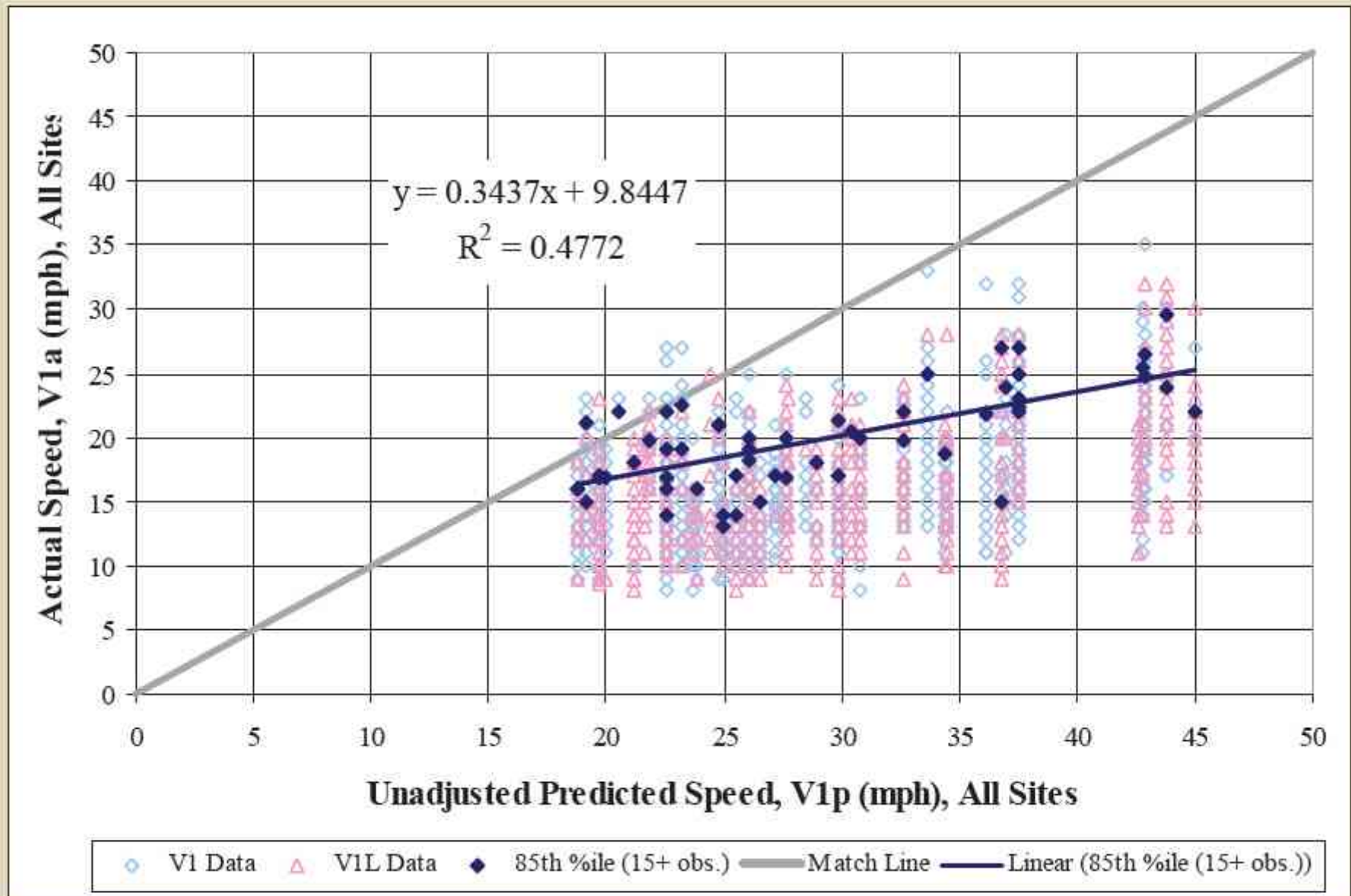


Roundabout speeds - Fastest Path



Note: R3 only matters if you haven't done your job with R1 or 2...
(R2 speed + possible acceleration to crosswalk is reality)

Design speed modeling: Entry speed (all sites), unadjusted



Proposed entry speed equation

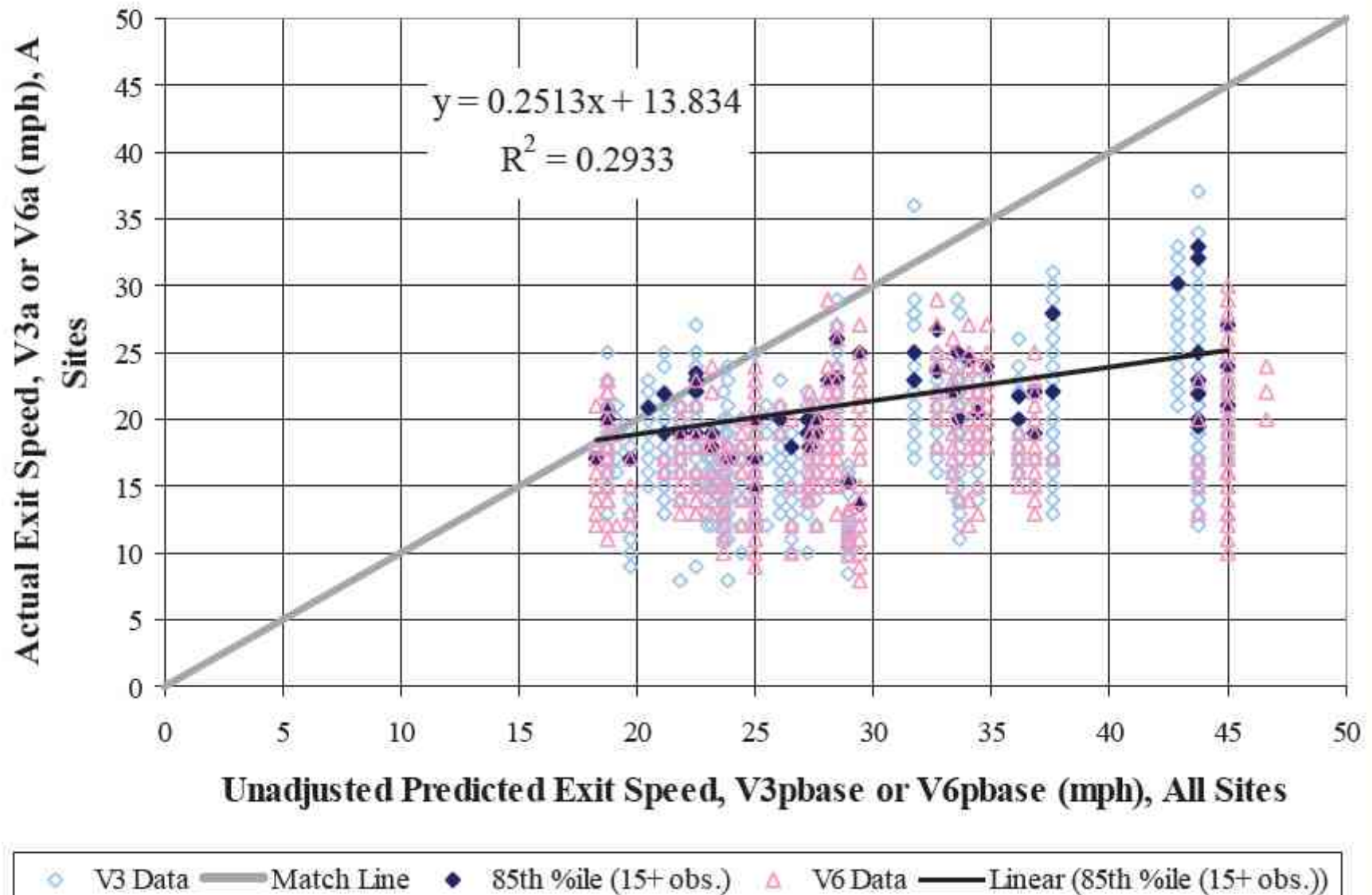
$$V_1 = \min \left\{ \begin{array}{l} V_{1pbase} \\ \frac{1}{1.47} \sqrt{(1.47V_2)^2 + 2a_{12}d_{12}} \end{array} \right\}$$

Speed where entry radius is limiting factor

Speed where circulating speed and deceleration distance is limiting factor

- where:
- V_1 = V_1 speed, in mph
- V_{1pbase} = V_1 speed predicted based on path radius, in mph
- V_2 = V_2 speed predicted based on path radius, in mph
- a_{12} = deceleration between the point of interest along V_1 path and the midpoint of V_2 path = **-4.2 ft/s²**
- d_{12} = distance along the vehicle path between the point of interest along V_1 path and the midpoint of V_2 path, in ft

Design speed modeling: Exit speed (all sites), unadjusted



Proposed exit speed equation

$$V_3 = \min \left\{ \begin{array}{l} V_{3pbase} \\ \frac{1}{1.47} \sqrt{(1.47V_2)^2 + 2a_{23}d_{23}} \end{array} \right\}$$

Speed where exit radius is limiting factor

Speed where circulating speed and acceleration distance is limiting factor

- where:
- V_3 = V_3 speed, in mph
- V_{3pbase} = V_3 speed predicted based on path radius, in mph
- V_2 = V_2 speed predicted based on path radius, in mph
- a_{23} = acceleration along the length between the midpoint of V_2 path and the point of interest along V_3 path = **6.9 ft/s²**
- d_{23} = distance between midpoint of V_2 path and point of interest along V_3 path, in ft

Implications for design

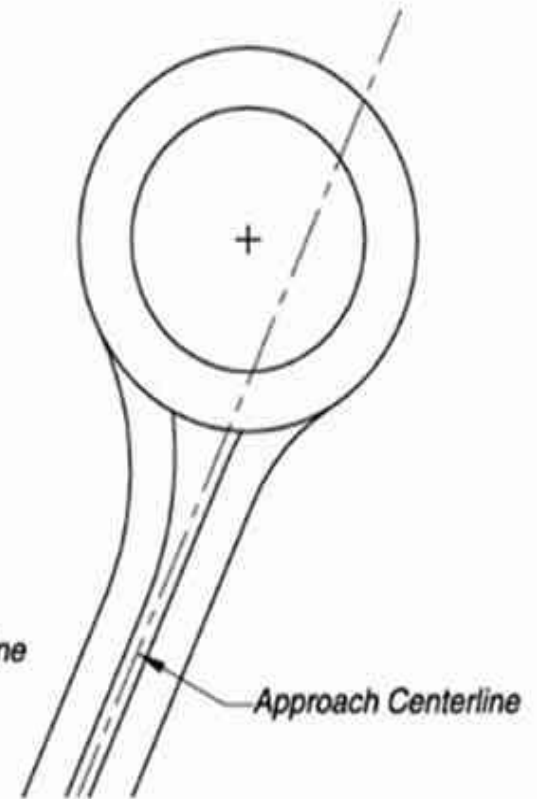
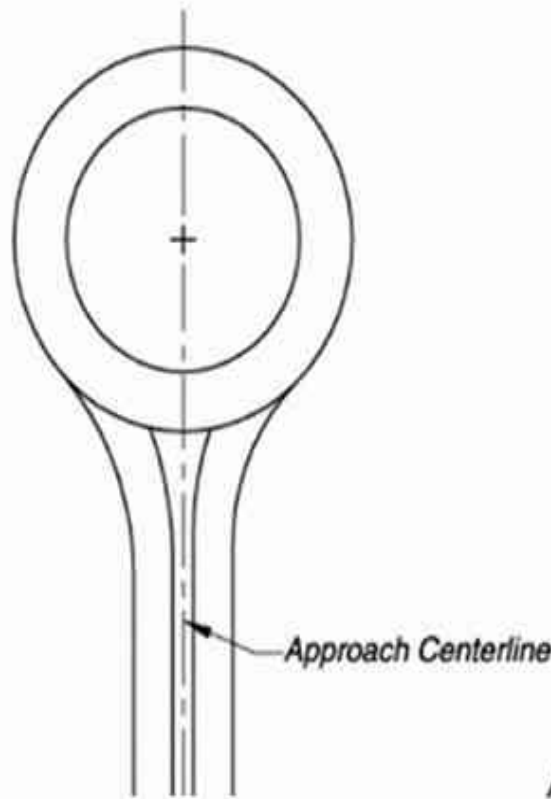
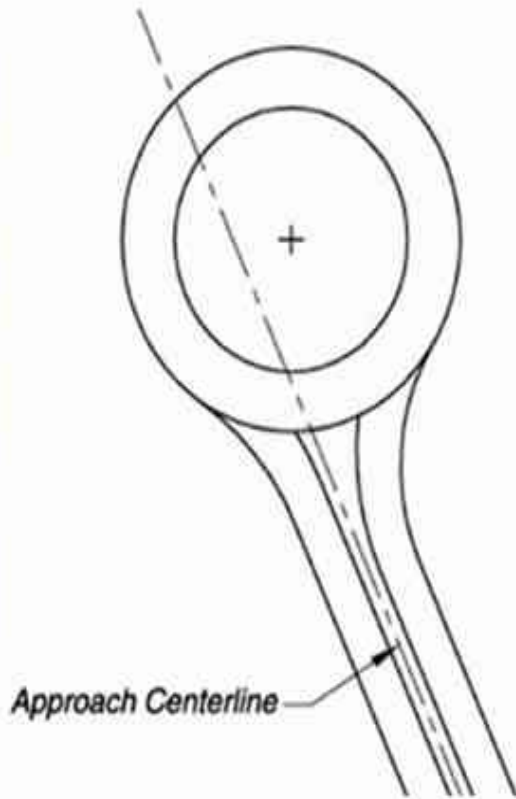
- **Tangential or nearly tangential exits do not appear to cause excessive vehicle exit speeds if the following conditions are met:**
 - *The speed of circulation (V2 and V4) is kept low*
 - *The distance between the start of the exit path and the point of interest (e.g., crosswalk) is kept short*
- **Entry speed appears to be limited by drivers' anticipation of the speed needed for circulation**
 - *However, recommend continued reliance on entry path curvature as a primary method to control entry speed*

Offset Left Preferred by Some States

Alignment Offset Left

Radial Alignment

Alignment Offset Right



PREFERRED

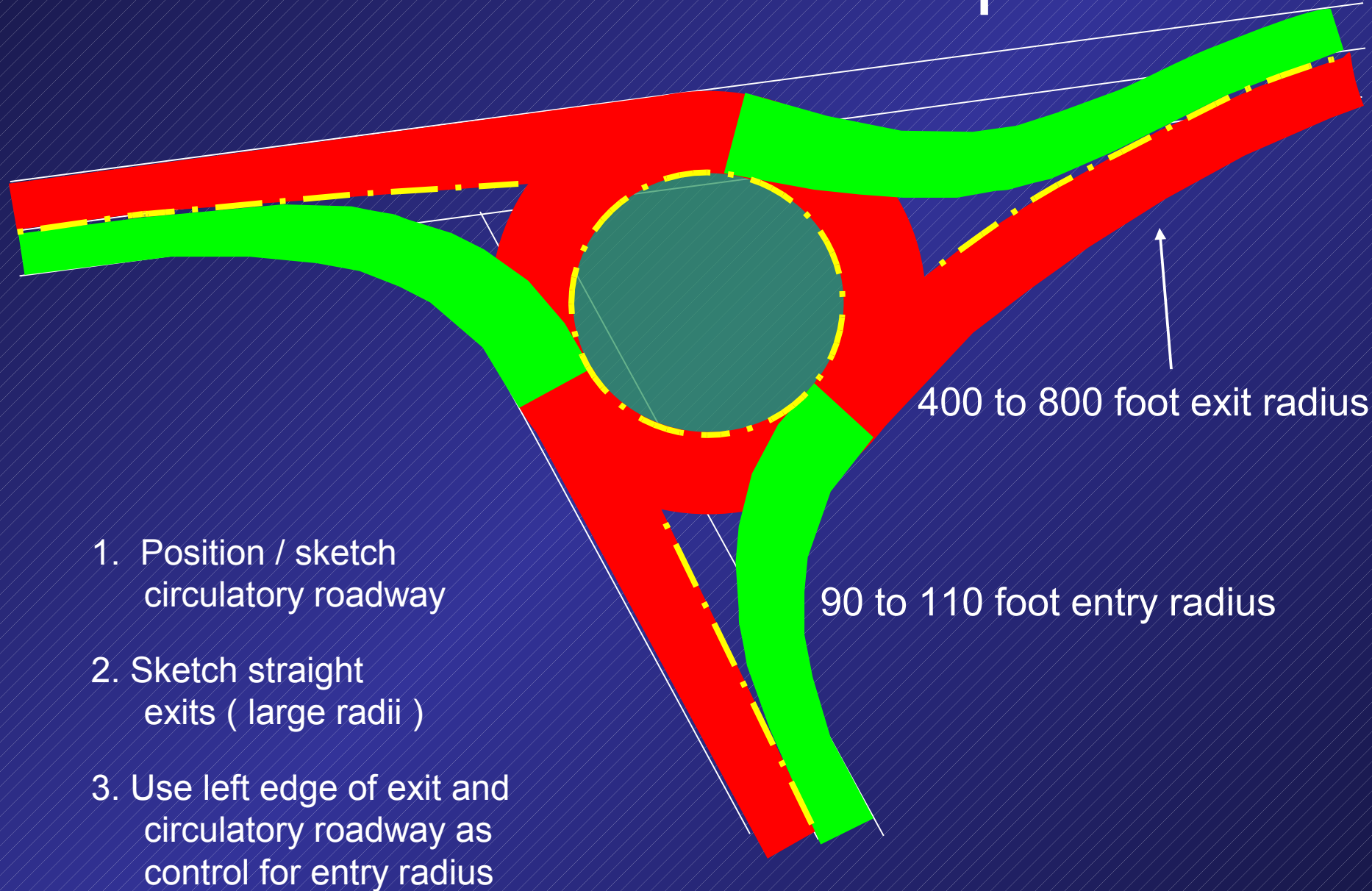
ACCEPTABLE

AVOID

Benefits of Left Offset

- Desired deflection is easier to achieve, especially with smaller diameter circle diameters
- Entry path overlap is easier to remove from multi-lane approaches
- Tangential exits (or large radius exits) remove the possibility of exit path overlap

Three Sketch Principles



Roundabout Capacity Software

- aaSIDRA
- RODEL / ARCADY
- SYNCHRO 6
- Results of NCHRP 3-65
- VISSIM
- PARAMICS

Two Types of Capacity Prediction Models

Gap Theory

- SIDRA, SYNCHRO, VISSIM, Paramics
 - Theoretical Capacity
 - “Seeing is believing”

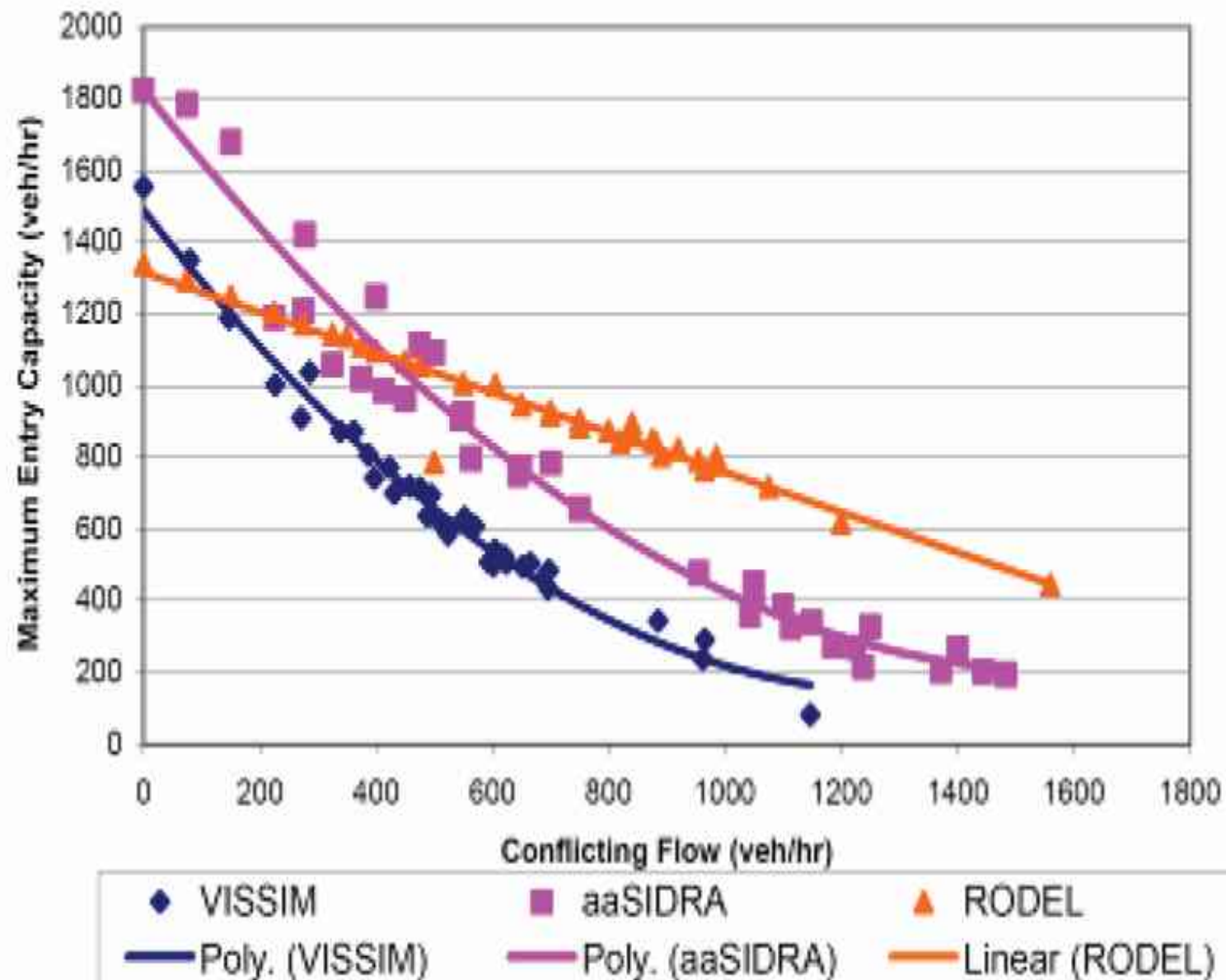
Empirical

- RODEL or ARCADY
 - Based on field measurements, not theory
 - Capacity measured during “at capacity” operation in U.K.

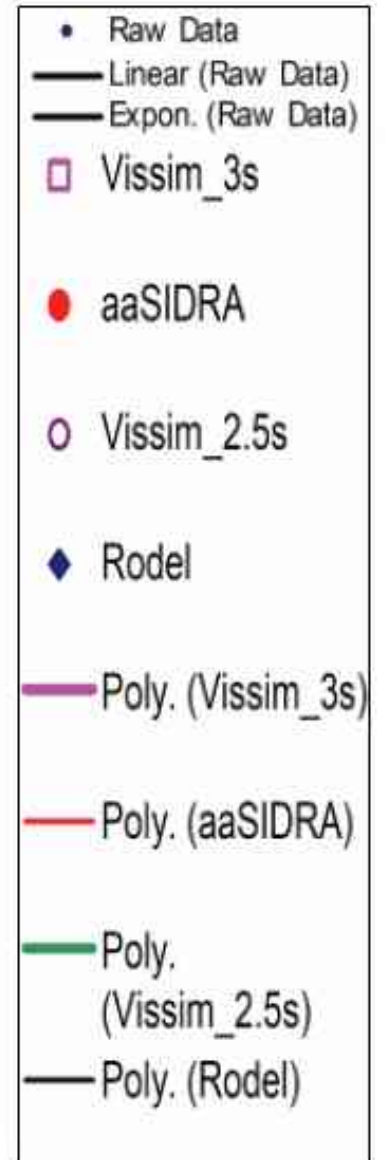
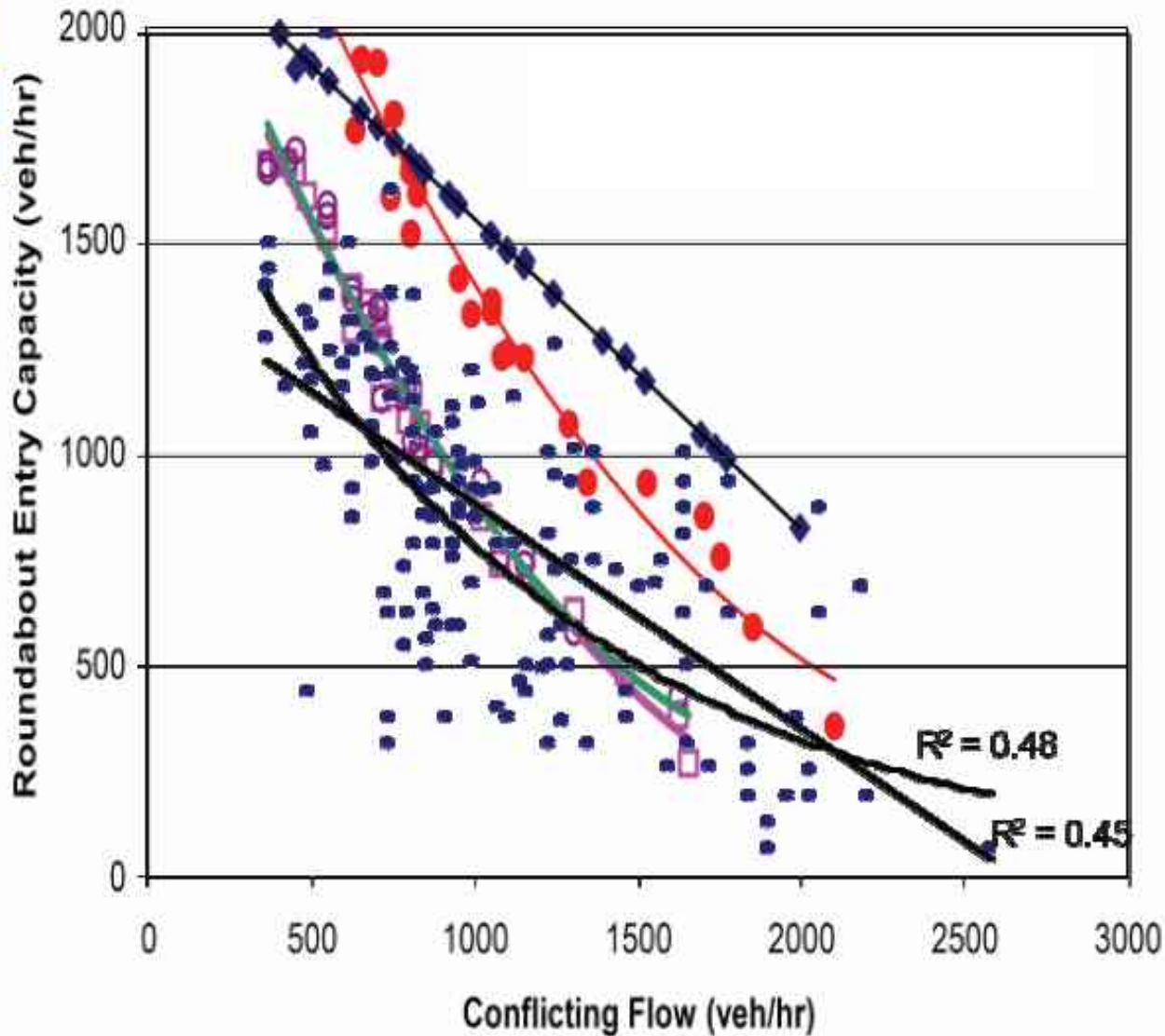
Note: They can give very different results

Roundabout Capacity Analysis

Comparison of VISSIM, RODEL, and aaSIDRA



Dual Lane Roundabout Plots





Conclusions and Future Research

- Simulated capacities of Single-lane roundabouts are noticeably lower than RODEL and aaSIDRA, however, they are comparable to fitted U.S field capacity data.
- Similarly, capacities of dual-lane roundabouts as simulated by VISSIM are significantly lower than RODEL and aaSIDRA, and are comparable to U.S field capacity data for a certain fitted regression.
- A roundabout placed within a signalized, coordinated arterial placed quarter mile from adjacent signals showed comparable delays to a fully signalized arterial. This finding is true when the roundabout is operating at or below capacity.



TABLE 3 Single lane roundabout - Comparison of VISSIM results with Real Data

Observation No.	Conflicting Flow (veh/hr)	Maximum Entry Flow (veh/hr)	
		Real Data (veh/hr)	VISSIM (veh/hr)
1	120	1020	1250
2	300	852	930
3	480	690	700
4	600	588	550
5	720	480	400
6	900	312	290


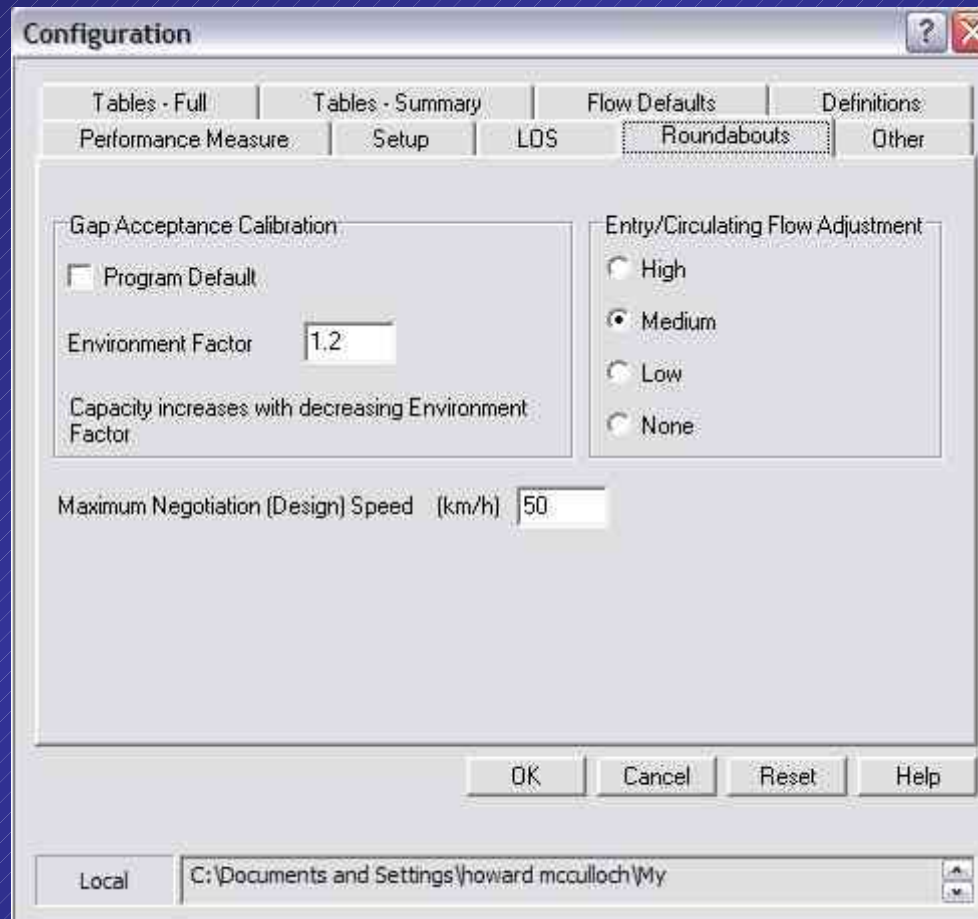


TABLE 4 Dual lane roundabout - Comparison of VISSIM results with Real Data

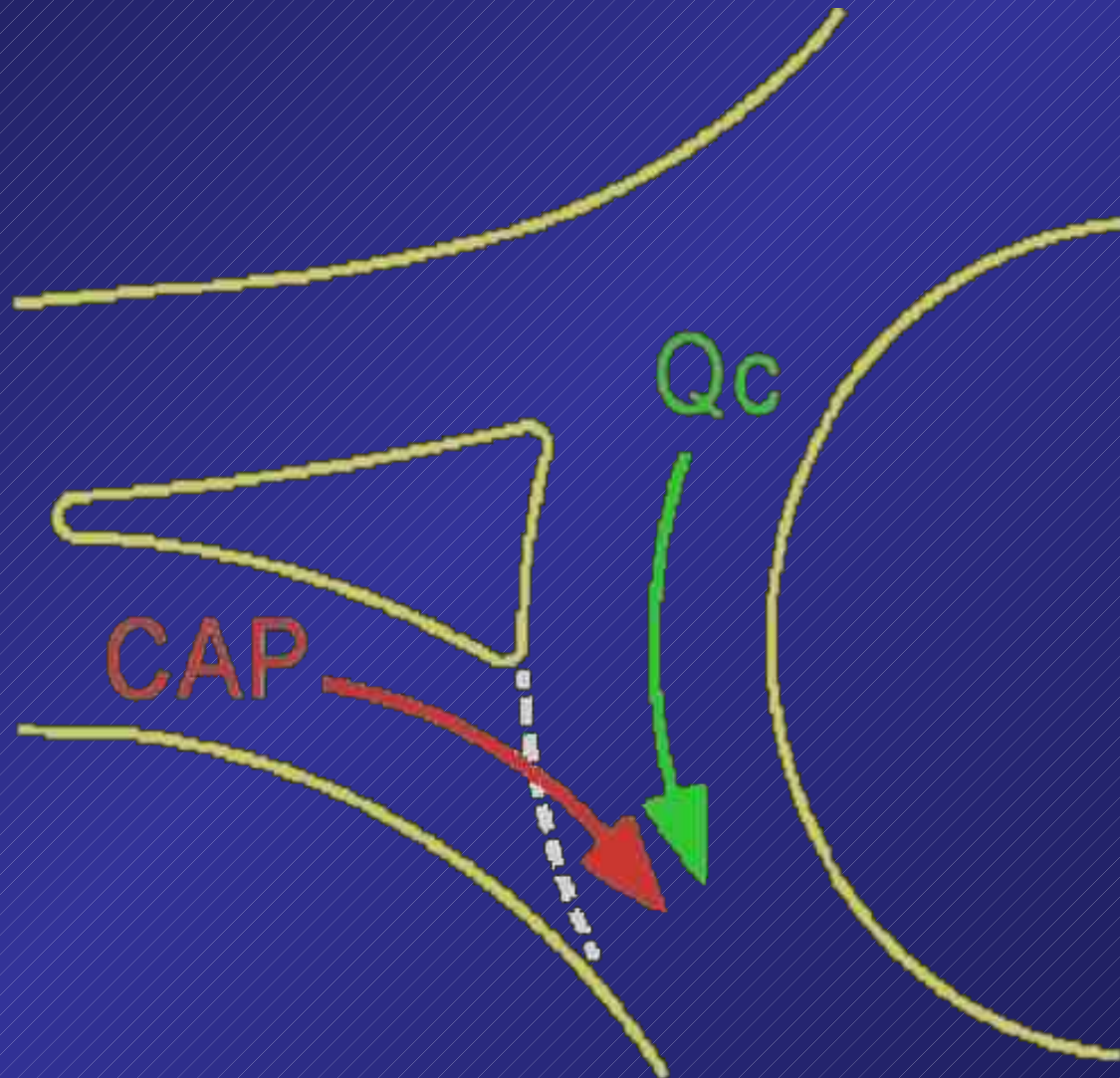
Observation No.	Conflicting Flow (veh/hr)	Maximum Entry Flow (veh/hr)	
		Real Data (veh/hr)	VISSIM (veh/h)
1	300	1620	1800
2	600	1290	1350
3	900	990	1000
4	1200	750	700
5	1500	552	450
6	1800	372	300

SIDRA

- Concerns over high capacity predictions with low circulating flows can be resolved – use 1.2 Environment Factor:



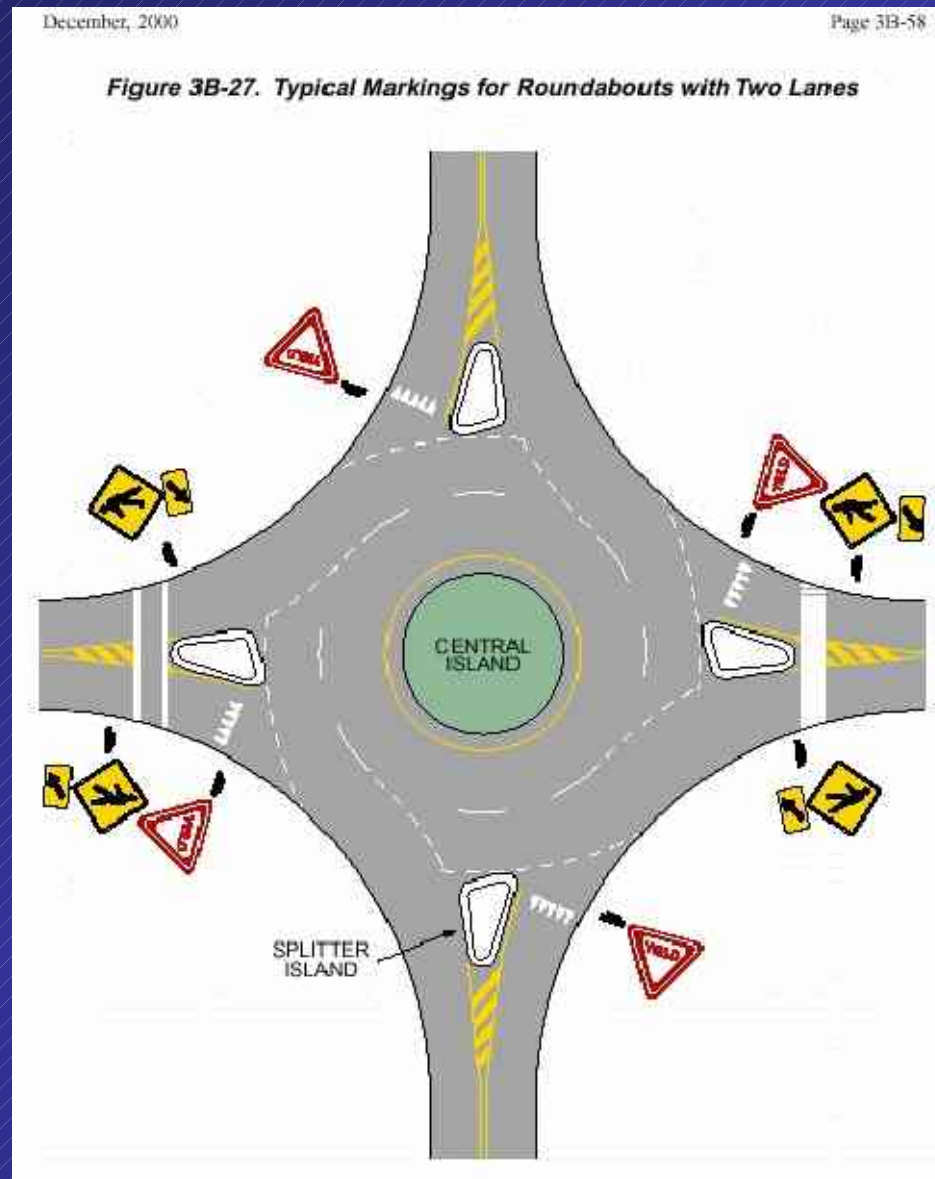
Capacity of an Approach – from RODEL



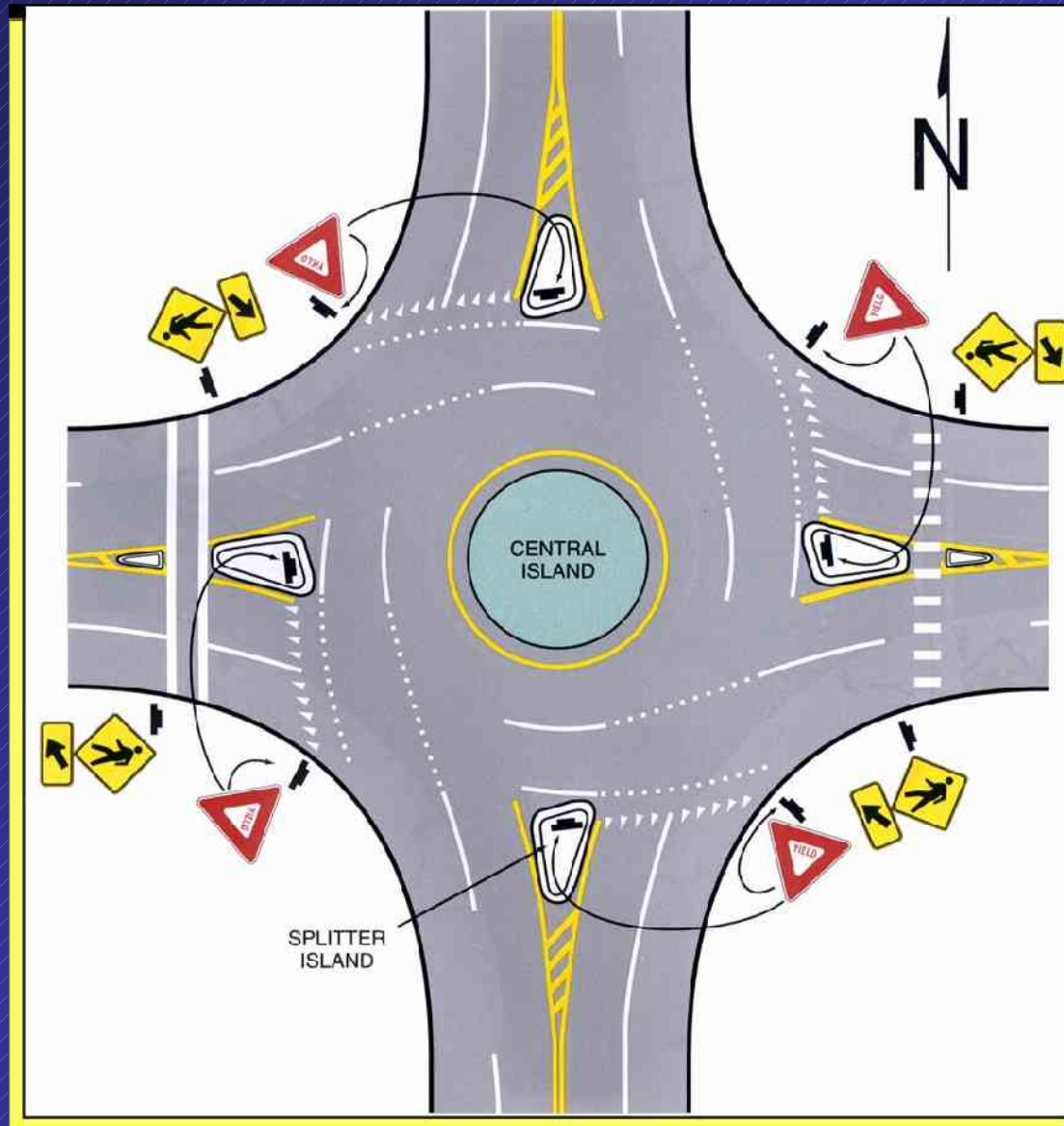
Simulation Programs

- Not typically used for roundabout design – are being used to visually check predictions
- Great tools for Public Info Meetings
- Able to show network impacts
- Visually displays improved performance provided by roundabouts
- VISSIM seems to be top choice
- Paramics is comparable but more expensive

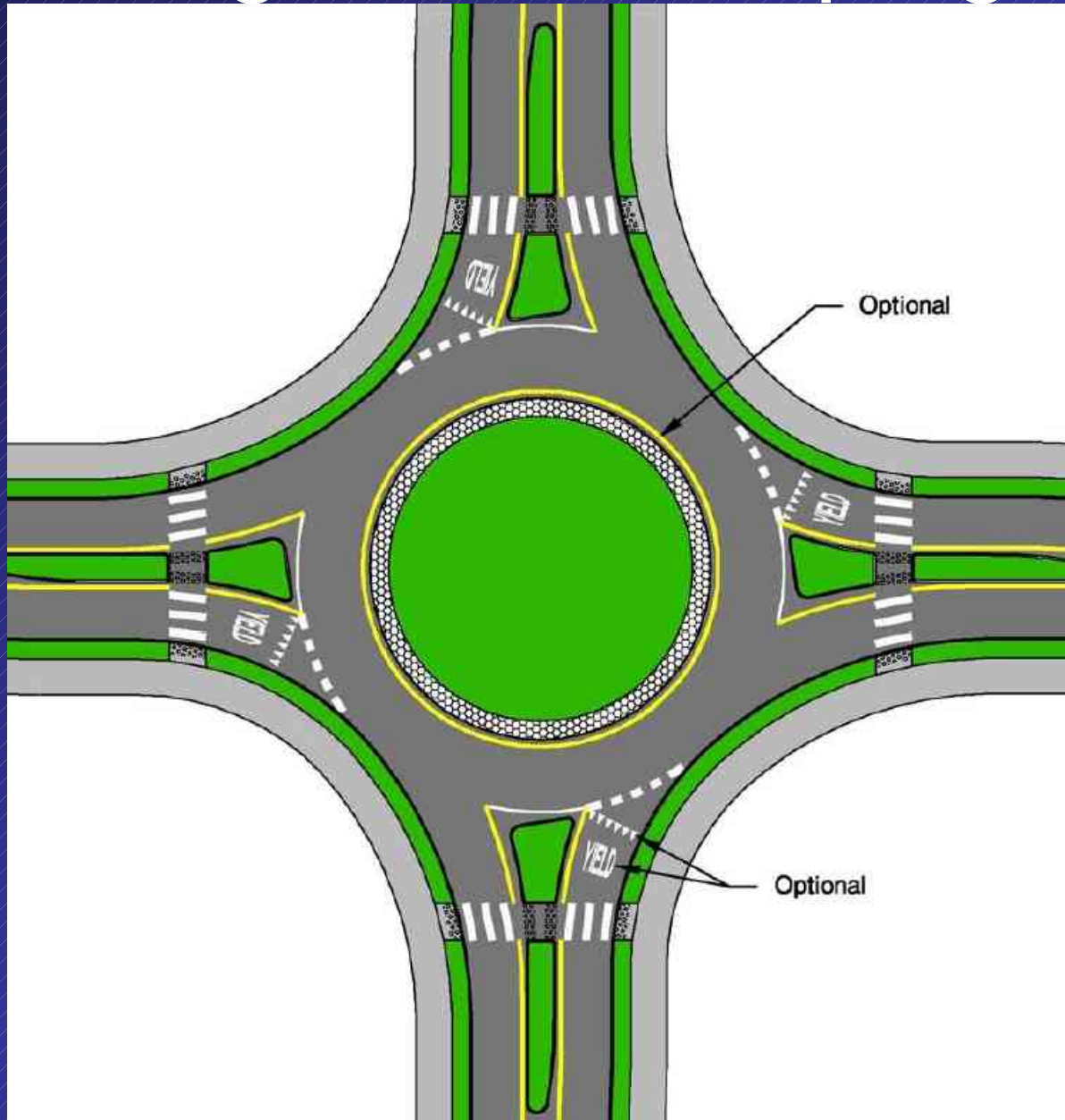
Striping - Millennium MUTCD



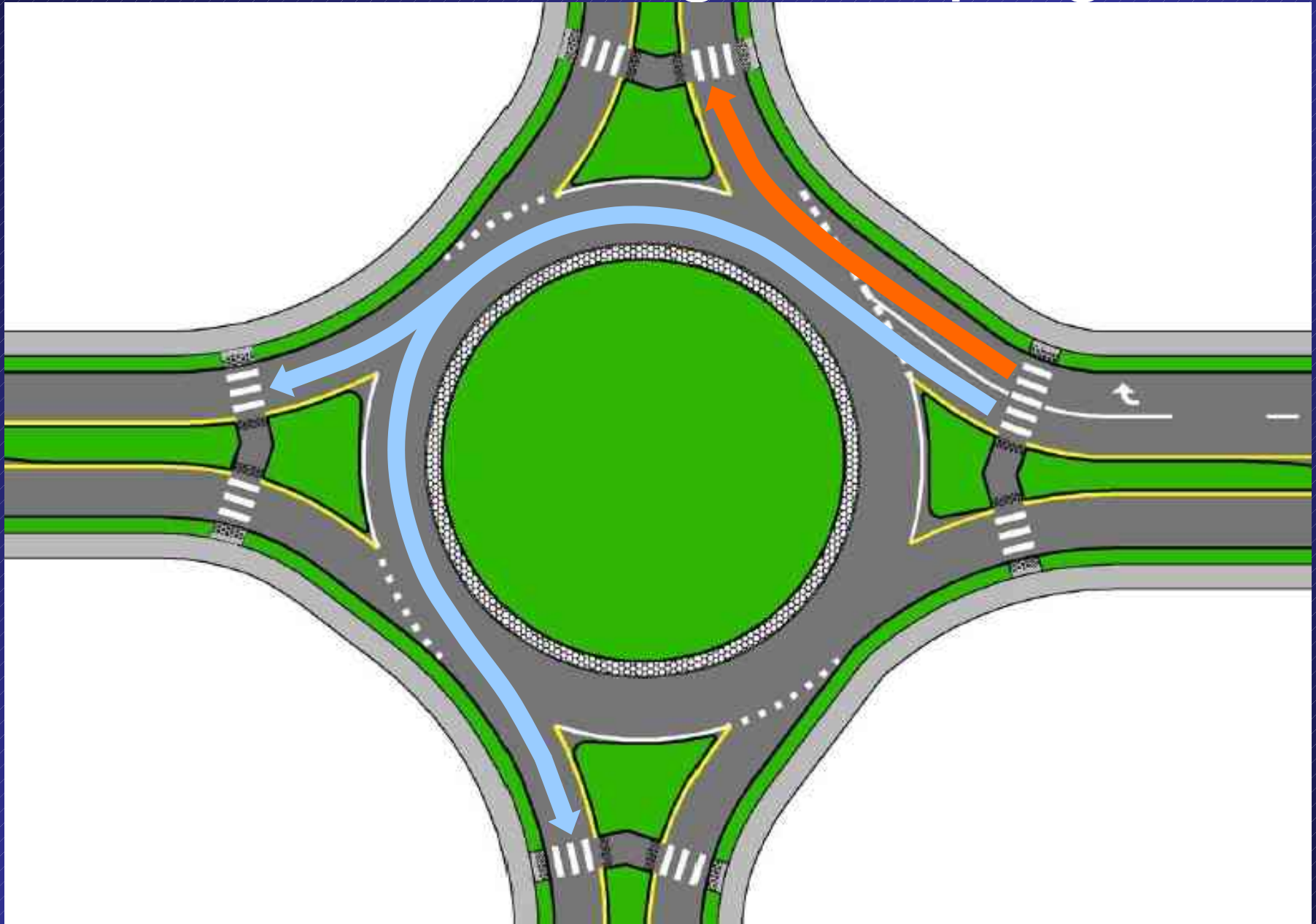
2003 MUTCD



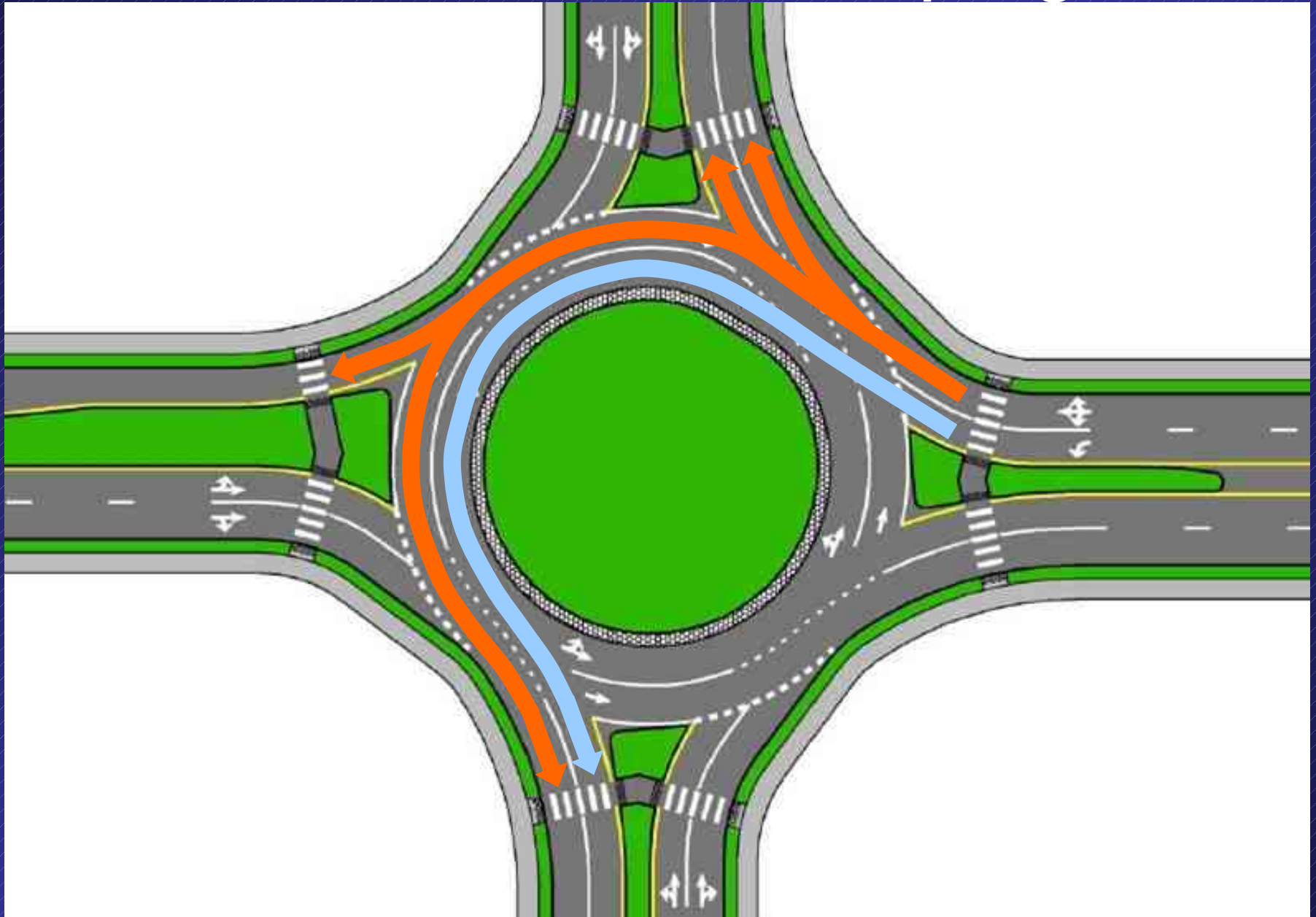
Single Lane Striping



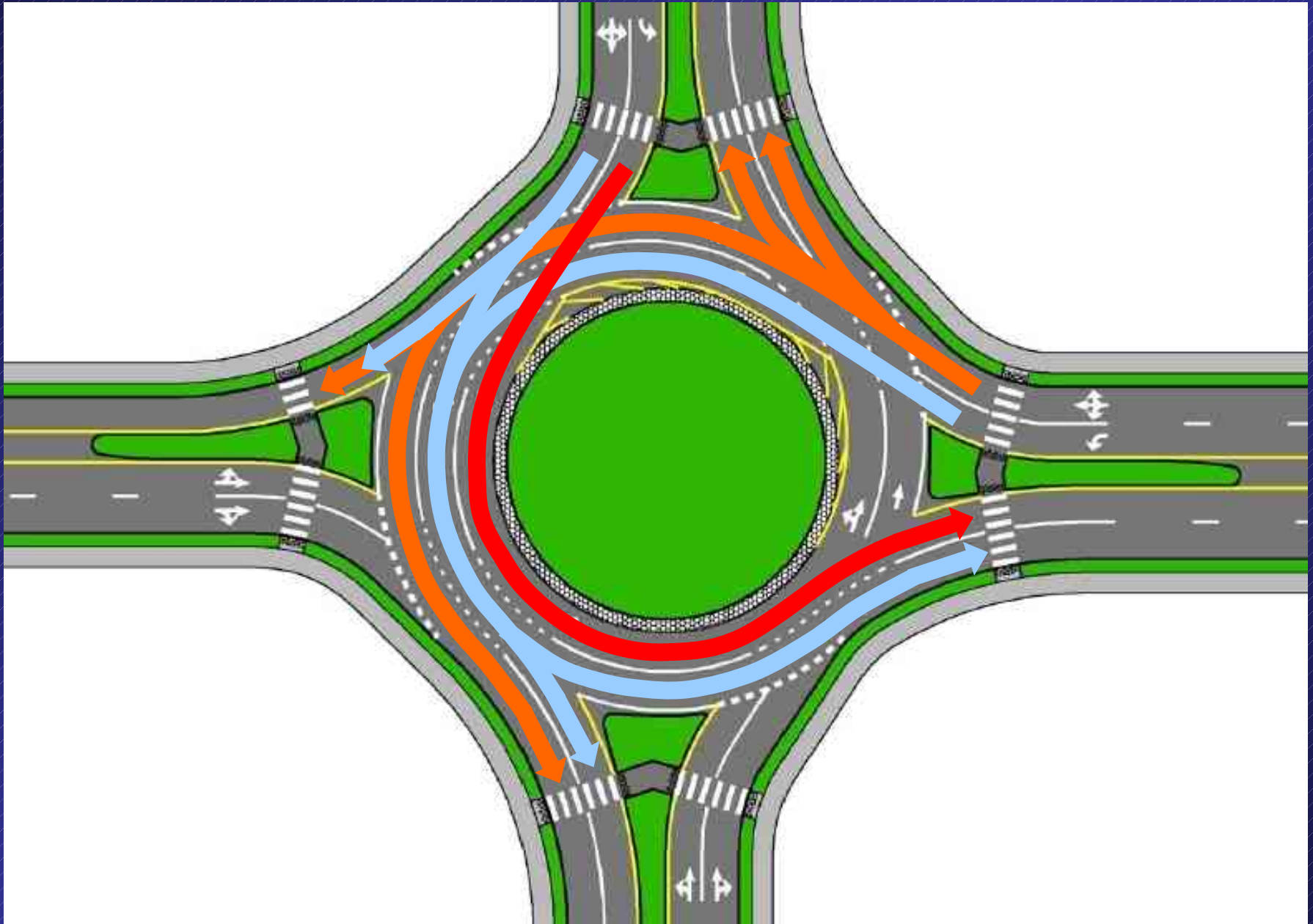
Dedicated Right Striping



Dedicated Left Striping



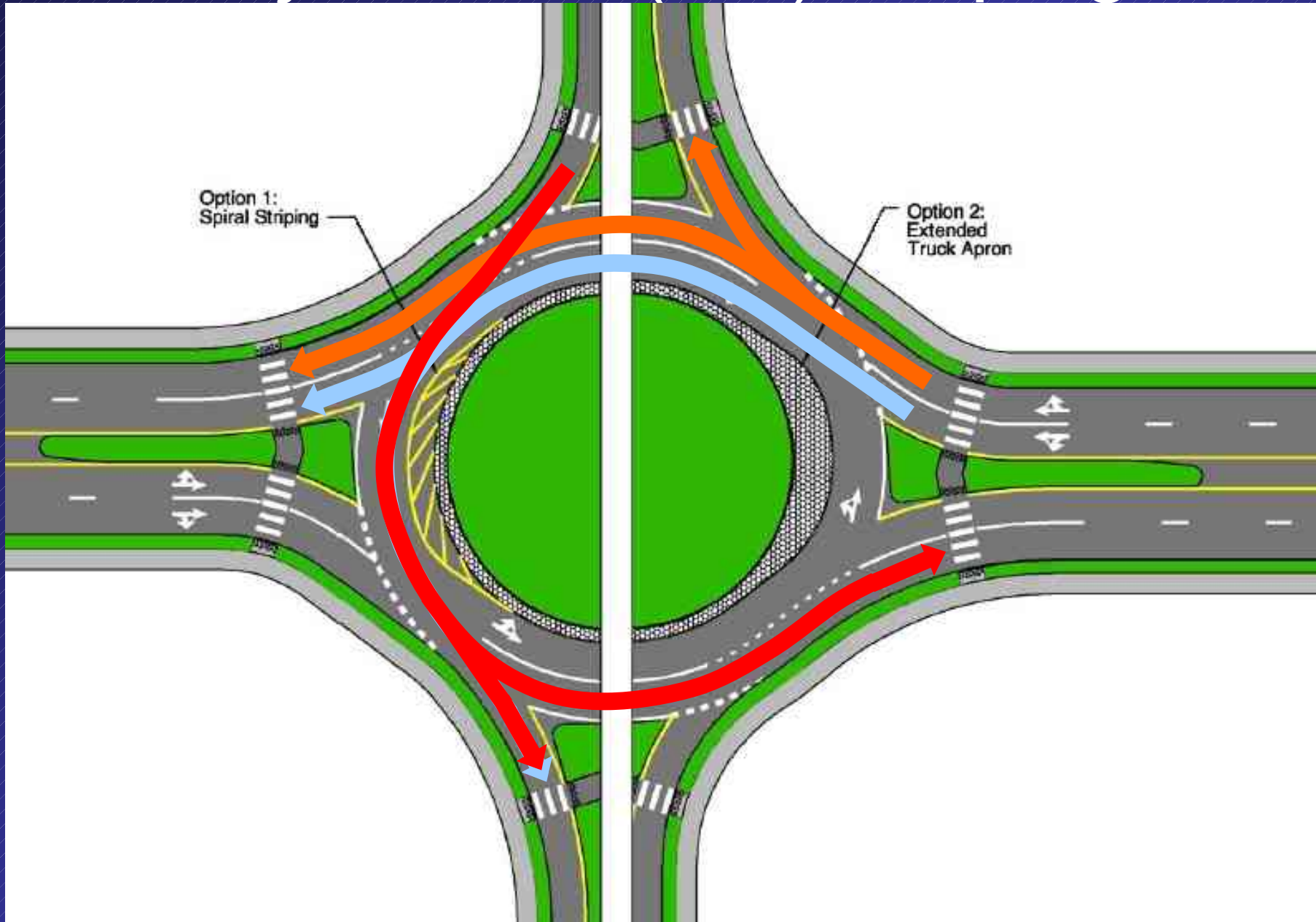
Consecutive Double Left Striping



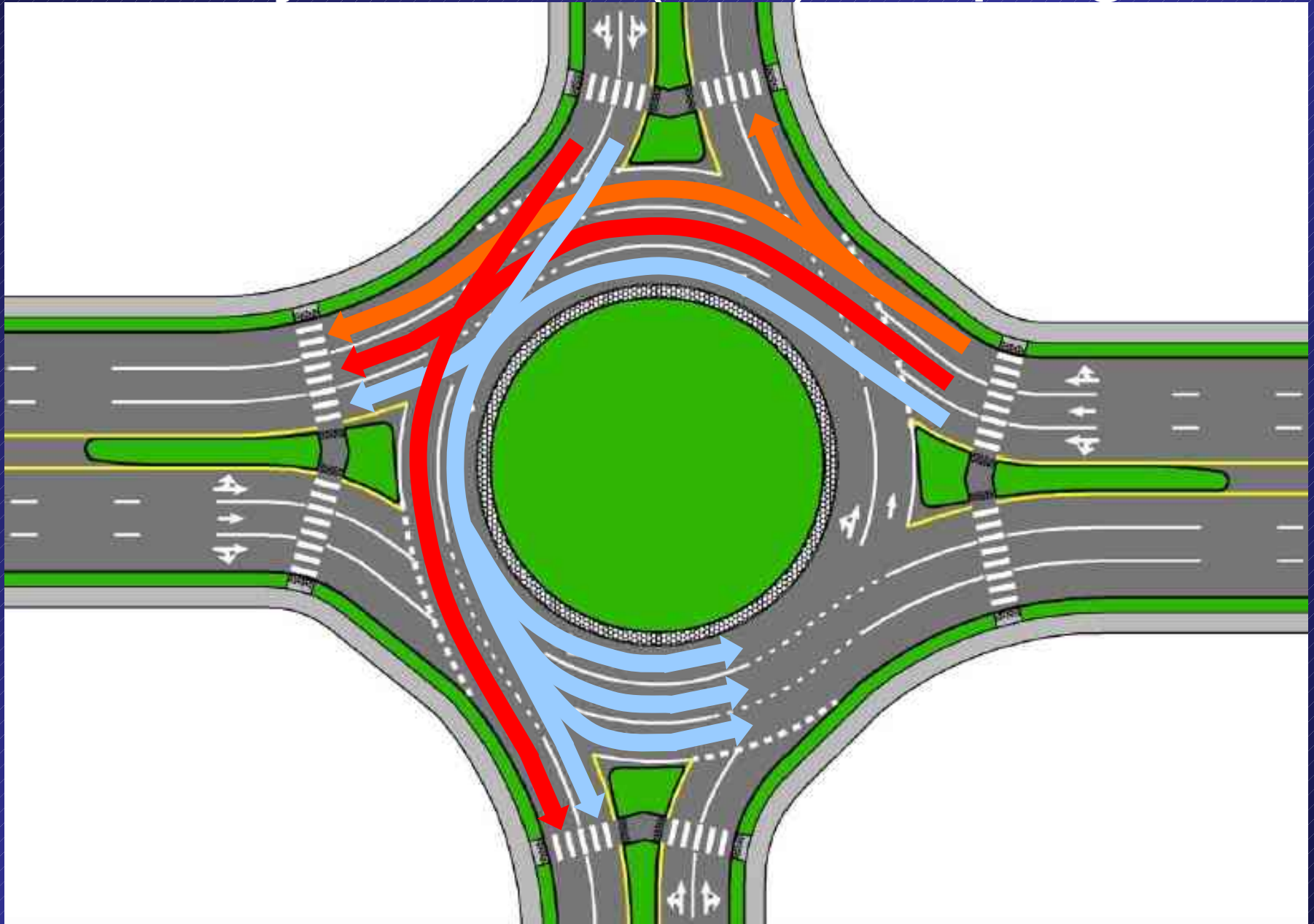
Major Major (full 2) Striping



Major Minor (2-1) Striping

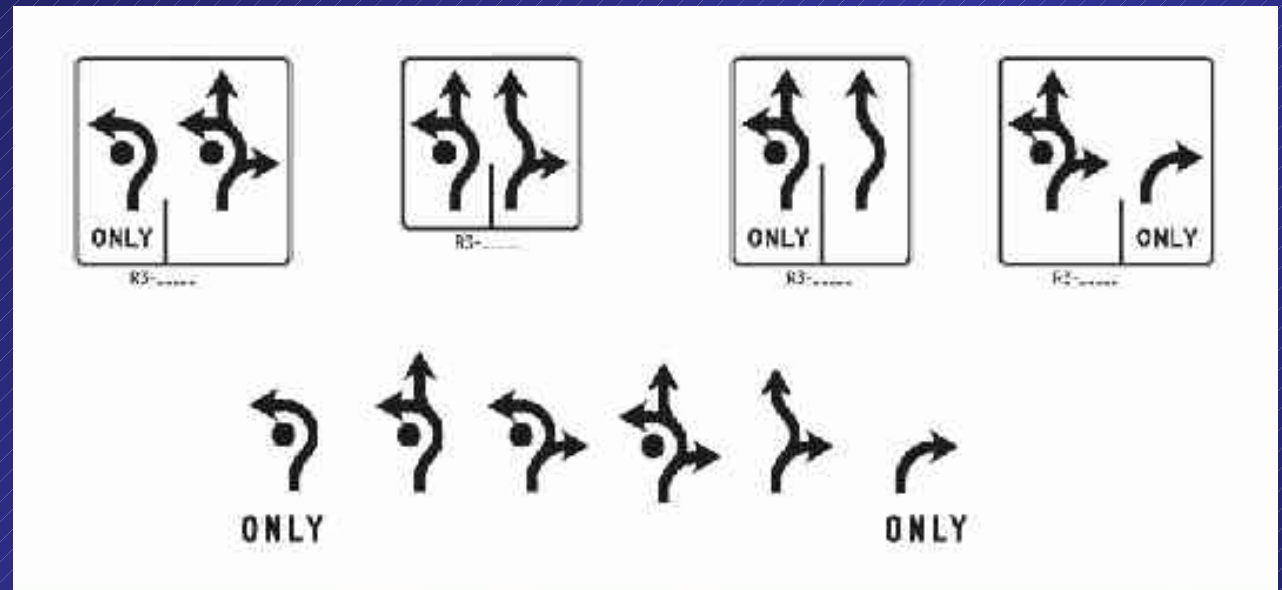


Major Minor (3-2) Striping

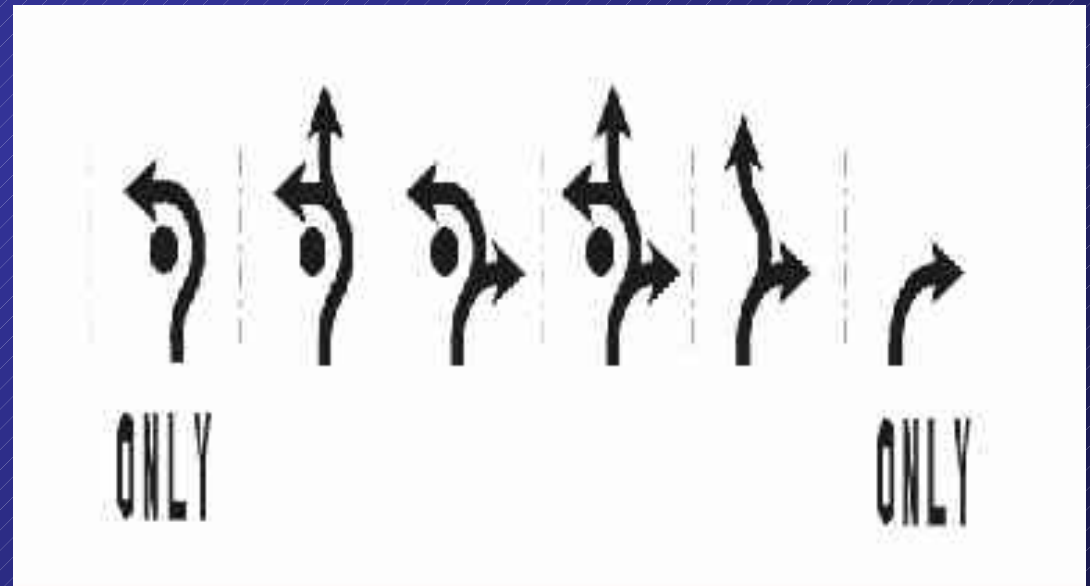


Fishhook Signing & Pavement Markings

Signs
with
fishhook
arrows



Fishhook
arrow
pavement
markings



Fish Hooks at Allwood, NJ Roundabout



ROUNABOUT LIGHTING

FHWA Roundabout Guide (2000): " For a roundabout to operate satisfactorily, a driver must be able to enter the roundabout, move through the circulating traffic, and separate from the circulating stream in a safe and efficient manner. To accomplish this, a driver must be able to perceive the general layout and operation of the intersection in time to make the appropriate maneuvers. Adequate lighting should therefore be provided at all roundabouts."


Florida: Florida DOT (FDOT) Roundabout Design Manual, Chapter 5.3 – Lighting – states on page 5-3, “For the roundabout to operate satisfactorily, the driver must be able to enter the roundabout, move through the circulating traffic and separate from the circulating stream in a safe and efficient manner. To accomplish this, the driver must be able to perceive the general layout and operation of the intersection in time to make the appropriate maneuvers. Appropriate lighting is therefore required at all roundabouts on state and local roads

The minimum light level set by the Florida DOT for roundabouts is 16 lux.”

Wisconsin: Wisconsin DOT's Facilities Development Manual, Chapter 11, Section 26 (Roundabouts), Subject 15, says, "A driver must be able to perceive the general layout and operation of an intersection in time to make appropriate maneuvers. Whenever a facility is designed for use by several user groups (motor vehicles, pedestrians and bicyclists or mopeds), the roundabout must be illuminated. Therefore, adequate lighting needs to be considered at all roundabouts"

Kansas: Kansas DOT Roundabout Guide, Chapter 7.3, says, “Lighting should be provided at all roundabouts, whether in rural or urban settings.” The specific lighting requirements for each setting are described below.

Lighting is required for roundabouts on the Kansas state highway system.”

To:		New York State Department of Transportation ENGINEERING INSTRUCTION	EI 06-000
Title: LIGHTING AT ROUNDABOUT INTERSECTIONS			
Distribution: (Check boxes-Use Vine Diagram 2-64 Symbol)		Approved:	
<input checked="" type="checkbox"/> Manufacturers (18) <input checked="" type="checkbox"/> Local Gov't. (31) <input checked="" type="checkbox"/> Agencies (32)		<input type="checkbox"/> Surveyors (33) <input checked="" type="checkbox"/> Consultants (34) <input checked="" type="checkbox"/> Contractors (39) <input type="checkbox"/> _____ ()	
		DRAFT Date _____	

Minimum Lighting Levels Required: are shown on the table below.



Illumination Required at Roundabout Intersections		
Highest 85% Approach Speed of entering roadway	Average Maintained Illumination at Pavement, lux/ft (Note 1)	Uniformity Ratio (Avg/Min)
50 km/hr or above (regular pedestrian use expected)	30 lux/3.0 ft	3:1
50 km/hr or above (few pedestrians expected)	20 lux/2.0 ft	3:1
Below 50 km/hr	15 lux/1.5 ft	3:1

Note 1 : The area of maintained illumination is defined as the polygon created by the crosswalks and the outer edge of the outer perimeter of the roundabout.

Lighting location: In general, the light standards should be located IN ADVANCE of the crosswalk to provide positive contrast for the crossing pedestrians, Yield signs, and other devices. The presence of more than occasional pedestrians requires the designer to check that crossing pedestrians are not "backlit" by the placement of lights beyond the crosswalk.

Center island lighting: The center island should have supplemental lighting provided by a light standard located in the center island when one or more of the following conditions exist:

- one or more of the approaches to the roundabout has an 85% operating speed of 80 km/hr or more.
- approach roadway geometry (eg, grade, sight distance, etc) and/or environmental conditions (eg, frequent foggy conditions) require the designer to increase the visibility of the roundabout for approaching vehicles.

The center island lighting should be full-cutoff and should be sufficient to illuminate the features within the center island, including signs and landscaping. The center light serves to augment the presence of the center island to allow vehicles more advance warning that the roundabout is ahead.

Approach Mounted Lighting (8) 250w H.P.S.



25 Lux

Existing Guidance

FHWA-RD-00-067 Roundabouts: An Informational Guide

Street Classification	Area Classification	Average Maintained Illuminance Values	Illuminance Uniformity Ratio (Average to Minimum)
Arterial	Commercial	17 lx (1.7 fc)	3 to 1
	Intermediate	13 lx (1.3 fc)	
	Residential	9 lx (0.9 fc)	
Collector	Commercial	12 lx (1.2 fc)	4 to 1
	Intermediate	9 lx (0.9 fc)	
	Residential	6 lx (0.6 fc)	
Local	Commercial	9 lx (0.9 fc)	6 to 1
	Intermediate	7 lx (0.7 fc)	
	Residential	4 lx (0.4 fc)	

- Illumination recommended for all roundabouts but not mandatory (rural with no other lighting)
- 80m transition lighting
- Recommends perimeter lighting and approach lighting
- Level should be sum of intersecting street levels

What's Next

Illuminating Engineering Society of North America Draft Guide

Illuminance for Intersections				
Functional Classification	Average Maintained Illumination at Pavement by Pedestrian Area Classification lux/ftc			E_{avg}/E_{min}
	High	Medium	Low	
Major/Major	34.0/3.4	26.0/2.6	18.0/1.8	3.0
Major/Collector	29.0/2.9	22.0/2.2	15.0/1.5	3.0
Major/Local	26.0/2.6	20.0/2.0	13.0/1.3	3.0
Collector/Collector	24.0/2.4	18.0/1.8	12.0/1.2	4.0
Collector/Local	21.0/2.1	16.0/1.6	10.0/1.0	4.0
Local/Local	18.0/1.8	14.0/1.4	8.0/0.8	6.0

- Vertical lighting levels equal to horizontal
- Approach lighting

NYSDOT Roundabout Design Unit

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